A SHIP'S STEERING UNIT WHOSE ANGULAR POSITION IS SERVO-CONTROLLED BY AN ELECTRIC MOTOR

[0001] The invention relates to a ship's steering unit comprising a mounting which is part of the structure of the ship, and in which a rudder is pivotally mounted, the angular positioning of said rudder being servo-controlled by a motor. The invention applies more particularly to a large ship such as a cruise liner in which the servo-controlling of the position of the rudder is assisted by machinery.

BACKGROUND OF THE INVENTION

[0002] Conventionally, the rudder is constrained to move with at least two hydraulic motors that are fed with oil under pressure by a hydraulic power unit. The hydraulic power unit itself has two electric motors powered by an electricity network to provide redundancy in servo-controlling the rudder. More particularly, the top portion of the rudder, which is mounted to turn about a vertical axis, is provided with a toothed ring situated in a horizontal plane, and each hydraulic motor has an outlet gear meshed with said ring to transmit servo-control torque to the rudder. That solution makes it necessary to implement one or more hydraulic power units associated with high-pressure pipes that take up a large volume and require specific maintenance.

[0003] In a more recent development, the ring is moved by means of electric motors, which makes it possible to omit the hydraulic power unit. In view of the power required to move the rudder, that solution results in increasing the number of

electric motors, and in equipping each of them with a gearbox, so as to guarantee that sufficiently high torque is transmitted. That configuration suffers from the drawback of being less compact due to the need to have a larger number of motors equipped with gearboxes, and it requires regular maintenance of said gearboxes in order to keep them in satisfactory working order.

SUMMARY OF THE INVENTION

[0004] An aspect of the invention is to remedy those drawbacks by providing an electrically servo-controlled steering unit that is compact, and that requires only a minimal amount of maintenance.

[0005] To this end, the invention provides a ship's steering unit comprising a mounting which is part of the structure of the ship, and in which a rudder is pivotally mounted, the angular positioning of said rudder being servo-controlled by a motor, wherein said motor is an electric motor comprising a stator rigidly fixed to said mounting, and a rotor rigidly fixed to said rudder. This motor, which is a steering motor, transmits the torque necessary for servo-controlling the rudder electromagnetically, i.e., without physical contact, which eliminates problems of wear. A fixed position is thus held by means of a power supply adapted to the type of electric motor in use. In the case of a synchronous motor, blocking in position is performed by injecting direct current (DC) into the rotor/stator windings. In contrast, in the case of an asynchronous motor, blocking in position is performed by adjusting the power supply frequency to match the rotor slip

frequency, i.e., by adjusting it to the same frequency, in such a manner as to zero the mechanical speed of the rotor. This configuration simplifies the steering unit by reducing the number of items of equipment that make up said unit, thereby making it easier to install on board and contributing to making it more reliable.

[0006] In an embodiment of the invention, the rudder includes a steering cone pivotally mounted in said mounting, and the electric motor is mounted inside said steering cone. The steering unit of the invention is thus made even more compact. The rudder includes an underwater portion that may be in the form of a rudder blade, or else in the form of a pod enclosing a propulsion motor for propelling said ship. When it is in the form of an underwater pod enclosing a propulsion motor that is cooled by a ventilation system, the steering motor may be cooled by diverting some of the ventilation provided for the propulsion motor. It is thus not necessary to implement additional ventilation means dedicated specially to cooling the steering motor.

[0007] In an embodiment of the invention, the stator has a plurality of electrical windings, each of which is powered by an independent source of electricity. The electricity sources may be dedicated power converters, thereby providing redundancy in the servo-control function, so as to guarantee that the steering unit of the invention operates reliably.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention is described in more detail below with reference to the accompanying drawings that illustrate

embodiments of the invention by way of non-limiting examples.

[0009] FIG. 1 is a section view of a steering unit of the invention.

[0010] FIG. 2 is a section view of a steering unit of the invention with multiple power converters.

DETAILED DESCRIPTION OF THE INVENTION

[0011] In FIG. 1, , a ship's steering unit comprises a rudder 1 pivotally mounted in a mounting 2 that is secured to or integral with the structure of the ship. In this example, the rudder 1 is provided with a steering cone 1' connected to the mounting 2 via a rotary mechanical coupling 3 enabling the rudder to turn about a vertical axis AX along which it extends. The steering cone 1' passes through the structure of the ship in watertight manner to hold an underwater portion 1" which is shown in part only. The underwater portion 1" is fixed rigidly to the steering cone 1' and it forms the active portion of the rudder 1 to steer the ship on a certain heading depending on its position about the axis AX. The angular position of the rudder 1 about the axis AX is controlled by servo-controlling the angular position of the steering cone which is situated inside the ship.

[0012] In the example shown in Fig. 1, the diameter of the steering cone 1' decreases from top to bottom, and it extends down into the mounting which forms a substantially complementary conical well. The rotary coupling 3 is situated in a horizontal plane at the top portion of the steering cone 1' that corresponds to the largest-diameter portion of the cone. A circular gasket 4 surrounds the small-diameter bottom

portion of the steering cone to provide sealing between it and the bottom portion of the mounting 2, which is also of small diameter. In prior art steering units, a ring provided with inwardly-facing teeth is generally mounted inside the top portion of the cone, so that hydraulic or electric motors having their outlet gears meshed with said inwardly-facing teeth are capable of turning the rudder about the axis AX.

[0013] In the embodiment shown in FIG. 1, a drive system using a toothed ring constrained to rotate with motors is replaced by a single large-diameter "steering" motor comprising a rotor 6 rigidly fixed to the rudder 1, co-operating with a stator 5 which is rigidly fixed to the mounting 2. The rotor 6 and the stator 5 are chosen to be of large diameter to facilitate transmitting large torque. Such a steering motor may be designed such that it surrounds the steering cone 1', or else it may be

[0014] mounted inside the steering cone so as to make the steering unit more compact, the choice being governed by dimensioning constraints corresponding in particular to the power the motor needs to deploy in order to achieve servo-control.

[0015] In the example shown in FIG. 1, the motor is mounted inside the top portion of the steering cone 1'. The rotor 6, which defines a substantially toroidal shape, is positioned in a horizontal plane while being fixed to the inside surface of the steering cone 1. It co-operates with the stator 5 which is also substantially toroidal in shape but which is of smaller diameter, and which is mounted inside the rotor 6 in the same

horizontal plane as said rotor. More particularly, the stator 5 extends down into the steering cone 1′ while being held at its top portion by a large-diameter circular cap 7 covering the steering cone and fixed rigidly to the mounting 2. In the example shown in FIG. 1, the stator comprises windings 5′ electrically powered by a power converter 8 such as a variable-voltage and variable-frequency converter connected to an electrical power supply network of the ship. In this example, the rotor 6 is passive and mainly comprises squirrel cages 6′ disposed around its outer periphery to co-operate with the stator to form an asynchronous motor. Implementing such an asynchronous motor offers the particular advantage of making it easier to block the rudder in position by adjusting the power supply to the motor to match rotor slip in such a manner as to zero the mechanical speed of said rotor.

[0016] This configuration comprises mounting the windings on the stator 5 rather than mounting them on the rotor 6 is advantageous when implementing a plurality of windings. In FIG. 2, each winding is powered by a respective dedicated power converter 9, 9′, 9″. The quantity of wiring is increased, but said wiring is connected to the stator 5, which is stationary, and said wiring is therefore easier to install. Implementing a plurality of separately-powered windings also provides redundancy in the position servo-control function, thereby improving the operating reliability of the steering unit of the invention.

[0017] The underwater portion 1″ of the rudder 1 of the invention may be a rudder blade, or else it may be a pod

enclosing an electric motor for propelling the ship. When it is a pod 1" enclosing a propulsion motor, the propulsion motor is generally cooled by a ventilation system causing air to flow through the pod. The flow of air is taken into the top portion of the steering unit via a circular opening 7' provided in the cap 7, as indicated by the arrow R in the figure. In the invention, the flow of air is also used to cool the steering motor, so that it is not necessary to provide additional means dedicated to cooling the motor for angularly positioning the steering unit.

[0018] The invention is not restricted to the above-described embodiment in which the steering unit includes a conical coupling, but rather it is also applicable to other types of mechanical coupling between the rudder and the mounting.